ELEMENTS OF RETAIL SHOPPING CENTER DESIGN

by

Paul C. Box

President, Paul C. Box and Associates, Inc.

Scottsdale, Arizona

FOREWORD

The history of shopping center development has been one of 'waves' since World War II, as population spread to the suburbs. Designs and techniques for accommodation of the vehicular traffic access so utterly essential to services of the centers were undertaken by architects and civil as well as the nascent traffic engineering profession - -often on a trial and error basis.

With experience, concepts were developed which worked well and a cadre of traffic professionals arrived. The breed is now passing along and a need exists to summarize and retain their knowledge for posterity. Early in the 21st Century, an ITE Committee TPC-101-03 Principles of Shopping Center Design was formed for this purpose. However, it concentrated on Regional size centers, while admittedly the most complex and 'interesting' to design, were also the fewest new ones to develop. For various reasons, the committee lost interest and the project was dropped.

There is a wealth of published research of interest and importance to shopping center designers that needs to be recognized and preserved. This Elements booklet identifies many of these as it reviews the scope of design for shopping centers of all sizes. Some material - -particularly on Regional malls- - has also been drawn directly from drafts of the ITE Committee project, by courtesy of its chairman Fred Gorove.

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CHAPTER 1
INTRODUCTION

Purpose and Scope

The intent of this document is to consolidate a review of the myriad elements associated with conventional shopping centers, ranging from a neighborhood 7-11/barber shop 'center' to a regional mall. It should be useful to the architect, the consulting traffic engineer, and to governmental zoning, building and review officials. The developer also needs to understand the importance of site location and design - -particularly off-site improvement needs such as widening of nearby intersections and access streets and even installation of traffic signal controls for high-volume driveway connections. Critical to financial success of the enterprise may be alleviation of existing congestion (often in cooperation with the governmental unit owning the public road) and - -above all, paying for improvements necessary to avoid any worsening of existing conditions.

The importance of an adequate parking supply is so well known to both developers and local governmental agencies, as to need no coverage here. Similarly, the development of appropriate traffic impact studies has been extensively covered in several presentations.(1), (2), (3) Emphasis here is therefore on the essential design elements. While regional size shopping centers have the most complex and demanding design issues, only a relatively few such developments are currently being considered versus innumerable neighborhood and community type centers. Therefore, this document addresses design of all types; with many of the features being common to each other.

Much useful research exists in publications that have been withdrawn or updated in different content/format, and this trend is expected to continue. An important part of this Elements summary is the identification of appropriate prior work. Therefore, copies of most references have been filed with the Elements publisher and should be available upon request to them.

Classification of the Development

Several ways exist of classifying shopping centers. One is by size in terms of GLA (Gross Leasable Area). During the surge of retail shopping center developments in the period 1950-1980, three rather distinct types were found:(1)

- Neighborhood (30,000-100,000 S.F.)
- Community (100,000-300,000 S.F.)
- Regional (300,000-1,000,000 S.F. or more)

Subsequently, the sizes of these became blurred, as all types expanded and 'mini-regional' and 'mega-malls' were planned. Some new variations appeared:

- Fashion Center(1)
- Outlet Center
- Power Center
- Town Center
- Lifestyle Center

Neighborhood centers may, of course, be much smaller than 30,000 S.F. and Community types may exceed 1,000,000 S.F. A key factor in driveway design and access location is directional distribution of arriving and departing traffic. Good estimates are required to calculate design lengths of driveway reservoir areas and on-street turn lanes. Knowledge of the trade area and its population or dwelling unit distribution are critical to these estimates. Because trade area is largely related to function of the retail center, use of definitions, as given in Table 1, are likely better than size, alone, as advocated by the Urban Lane Institute.[4] The ICSC (International Council of Shopping Centers), New York, New York, has defined trade areas for eight types of centers in 2004.

TABLE 1. Definition of Shopping Centers by Function

TYPE	FUNCTION & TYPICAL RETAILERS
Neighborhood (Within a 5-10 minute drive) [4]	Serves local residents within 3 miles. Grocery, drug, beauty/barber shops, fast food restaurant, possible service station.
Community (Within a 10-20 minute drive) [4]	Serves larger area up to 3-6 miles. Jr. Dept. stores such as Target, Walmart, K-mart. Home improvement stores; Home Depo, Loew's. Fast food and formal restaurants. Possible theater, bank
Regional (Over 25-30 minute drive) [4]	Trade area related to competing sites - -may reach out 100 miles (West Acres, Fargo, ND; Westgate, Amarillo, TX). First line department stores, fashion clothing, formal restaurants, auto service, theaters.

Design Elements

Regardless of size or function, retail shopping centers are common in several respects, by having:

- One or more buildings housing the retail.
- A customer and employee parking facility.
- Provision for delivery of the retail goods.
- A method of access for both customers and trucks, and
- One or more public roads from which access is gained.

The design elements may be grouped into several general areas and their typical application identified by functional type of center. See Table 2. These are then discussed in detail in subsequent Chapters, using Table 2 as an outline.

TABLE 2. Design Elements Related to Shopping Center Sites

	TYPICAL APPLICATIONS BY SIZE OF CENTER		
ELEMENTS	Neighborhood	Community	Regional
<u>DRIVEWAYS</u>			
Radii	x	x	x
Width	x	x	x
Clear sight distance	x	x	x
Access point spacing/queuing	*	x	x
Turn lanes	*	x	x
Multi-lanes	*	x	x
Signal control	*	x	x
Reservoir space		x	x
Capacity		x	x
On-street turn lanes		x	x
<u>BUILDING FRONTAGE ROADWAYS</u>			
Widths	x	x	x
Centerlines	x	x	x
Crosswalks	x	x	x
Parking/loading use	x	x	x
<u>PARKING DESIGN</u>			
Aisle orientation to building	x	x	x
End island length	x	x	x
Wheelstops and other vehicle limits	x	x	x
Stall widths and angles	x	x	x
Aisle widths	x	x	x
Small car spaces	x	x	x
Color of stall markings	x	x	x
Color of hazard markings	x	x	x
One versus two-line stall markings	x	x	x
Lighting	x	x	x
Landscaping	x	x	x
Drainage and maintenance	x	x	x
Legal liability	x	x	x
<u>OTHER SITE ELEMENTS</u>			
Pedestrian and bike access	x	x	x
Provisions for truck load/unload	x	x	x
Loading court			x
Speed control		x	x
Avoidance of public traffic cut-through		x	x
Connector roads		x	x
Ring roads			x
Out parcel access		x	x
Transit accommodation			x
Garages			x
<u>Signs</u>			
TCD	x	x	x
Warning		x	x
Guide			x
Parking stall finding			x
<u>Roadway striping:</u>			
Ring roads			x
Driveway lane use			x

*Site specific possible application.

CHAPTER 2
DRIVEWAY AND BUILDING FRONTAGE ROADS

Driveway Dimensions

While somewhat dated (and currently under update development) the 1987 ITE Driveway Recommended Practice[5] dimensions remain pertinent today. For urban commercial use, they are:

Width:
15 feet minimum (1-way)
35 feet maximum (2-way)

Right turn radius:
10 feet minimum (low volume)
20 feet maximum (except signalized high volume or industrial)

Minimum spacing from street corner (radius end to radius end): 10 feet

Minimum angle from road alinement: 45 degrees

Figure 1 illustrates the application of these dimensions to most commercial developments..

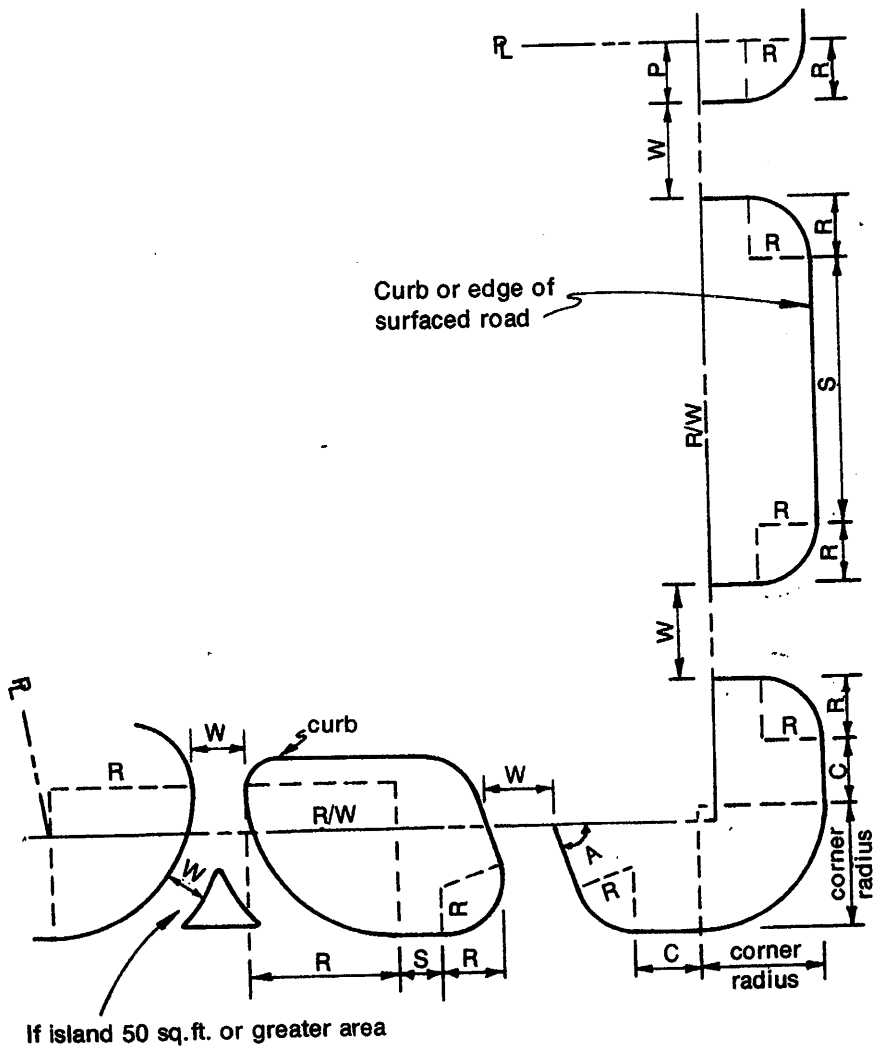

Figure 1. DRIVEWAY DIMENSION MEASUREMENTS
(Source: Ref. 5, Figure 8)

In practice, desirable dimensions for a relatively low volume, 2-way retail driveway are a 30-foot width and 15-foot radius on each side, as shown on Figure 2 from the ITE Practice.[5] Radii are an important but often overlooked element in driveway operation. The upper part of Figure 2 represents the actual design fostered by the State of Wisconsin on a main Community size shopping center driveway "because that was the City standard." Ironically, the state design required a 35-foot radius at a nearby intersection, where the right turn volume was but a small fraction of that at the driveway!

The distance from a signalized intersection on the approach side is desirably greater than 10 feet, although one research study found no significant relation between accidents and low volume driveway setback.[6] For higher volume driveways, other factors apply which are covered subsequently.

Of particular relation to shopping centers is the need to increase driveway dimensions for higher volumes. While the 30-foot width is adequate for a small Neighborhood center, the main driveway of a Community-type likely needs 2 lanes for exit - -1 marked for right turns and 1 for left turns. A single, wider inbound lane will usually suffice, giving a total width of 36 to 40 feet. For the signalized access point of a Regional center, a 4-lane driveway is likely a 'must' and is usually designed with a median separator.

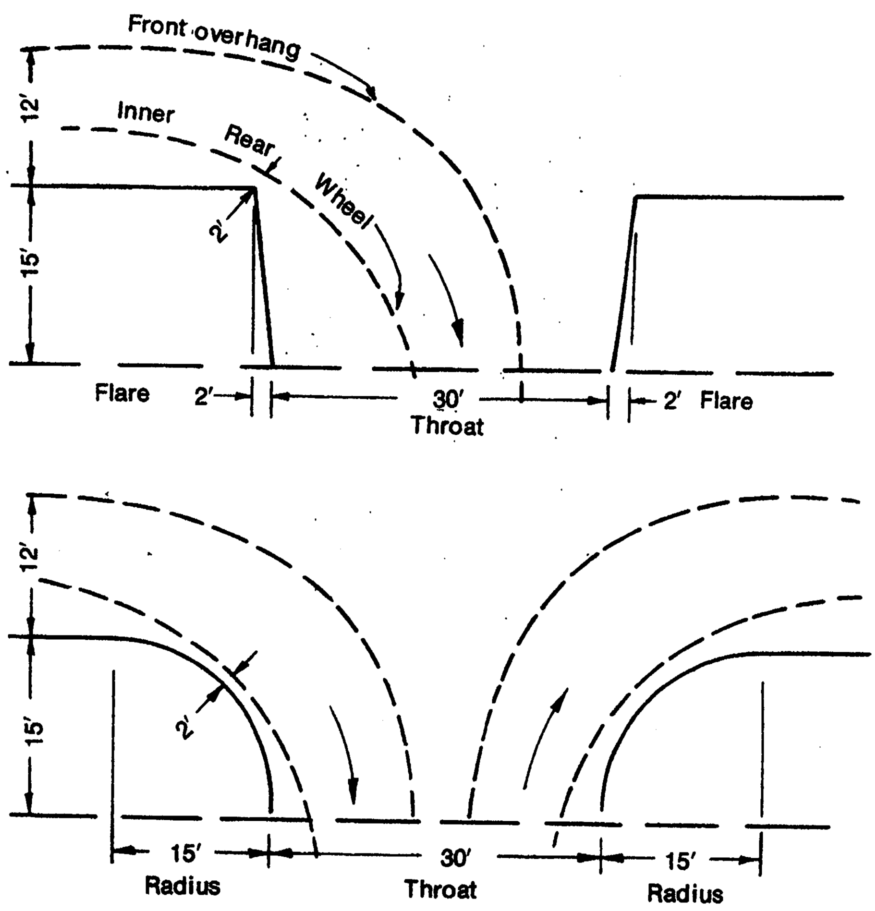

Figure 2. SWEPT PATH OF PASSENGER CAR TURNS FROM 12-FOOT CURB LANE, ILLUSTRATING NEED FOR ADEQUATE RADIUS; INSTEAD OF A NARROW FLARE. (Source: Ref. 5, Figure 3)

Clear Sight Distance

The importance of adequate sight distance cannot be over-emphasized. Each driveway represents at least a minor intersection as recognized by the American Association of State Highway and Transportation Officials.[7] Drivers exiting onto a public road need clear visibility of any adjacent sidewalk users, bikers on the walk or in the road, and approaching vehicular traffic, unless under traffic signal control. Shrubs, bushes or hedges adjacent to the public right-of-way should be of a type not exceeding 24 to 30 inches when fully grown. The lower limbs of trees should be no less than 8 feet up. Walls or embankments should not extend over 30 inches above the driveway grade. Signs near the exit should be lower than 30 inches, or measure at least 8 feet to the bottom.

Relative to visibility along the public road, the ITE Practice[5] states "Before issuing a permit for egress from a parcel of land, the responsible agency should ensure that vehicles can exit from a proposed development with minimum hazard and disruption of traffic." The Practice presents six tables designed to enable drivers to:

- Upon turning left or right out of a site, accelerate to the operating speed of the road without causing approaching vehicles to reduce speed by more than 10 MPH, and

- Upon turning left into a site, clear the near half of the road without conflicting with vehicles approaching from the left.

These ITE computations have been consolidated into Table 3 for passenger cars and Table 4 for trucks with trailers.

TABLE 3. Safe Sight Distance Along Roadways for Passenger Cars

	Sight Distance (feet) for Roadway Operating Speed (MPH)				
MOVEMENT	20	30	40	50	60
Exiting onto 2-lane road Left Right	 150 130	 350 260	 530 440	 740 700	 950 1050
Exiting onto 4 or 6-lane road Left Right	 130 130	 220 260	 380 440	 620 700	 950 1050
Exiting from 2-lane road	150	230	370	520	700
Exiting from 4-lane road	160	250	390	550	740
Exiting from 6-lane road	170	270	420	580	780

Source: Ref. 5, Tables 3, 4 and 7.
NOTE: Add 10% for rural roads.

TABLE 4. Safe Sight Distance Along Roadways for Trucks With Trailers

	Sight Distance (feet) for Roadway Operating Speed (MPH)				
MOVEMENT	20	30	40	50	60
Exiting onto 2-lane road Left Right	 300 200	 500 400	 850 850	 1600 1600	 2500 2500
Exiting onto 4 or 6-lane road Left Right	 200 200	 400 400	 850 850	 1600 1600	 2500 2500
Exiting from 2-lane road	260	400	570	810	1000
Exiting from 4-lane road	280	440	620	880	1100
Exiting from 6-lane road	300	480	670	950	1200

Source: Ref. 5, Tables 5, 6 and 8.
NOTE: Add 10% for rural roads.

Access Point Spacing/Queuing

The AASHTO[7] state that "Ideally, driveways should not be located within the functional area of an intersection or in the influence area of an adjacent driveway." However, such a policy would prohibit access to many properties lying within hundreds of feet of the intersection of two major routes. It would eliminate most service station driveways, for example, and result in effectively removing the legal right-of-access from many properties, without compensation. Perhaps in consideration of this, few agencies have been found to regulate this 'ideal' access control.

A major detailed study that examined intersection effect on driveway accidents found the relation was:[6]

- Only 1.2% of total accidents and 6.3% of driveway accidents in one city
- Only 2.0% of total accidents and 6.9% of driveway accidents in a second city

Neither of the cities placed any limitation on driveway proximity to intersections, other than clearing the corner radius.

The AASHTO 'functional area' includes right turn lanes but no research has been found that a driveway in such a lane creates any safety or operational problem (of course, a high volume driveway in this location would be inappropriate).

Relative to adjacent driveways, the level of activity of such an access point is an important criterion. Research cited by AASHTO [7] were that 20% of through vehicles were impacted at about 172 feet or more in advance of a driveway at 30 MPH, or at 345 feet at 50 MPH. Lest these dimensions be considered to represent desirable spacing between driveways, it should be noted that the volume of right turns into the adjacent driveway needs to be considered, as well as the effect of a proposed driveway on a preceding one. To briefly summarize, a truck access driveway into a Community or Regional shopping center can be located a few hundred feet prior to or beyond a major access point without fear of conflict, because the activity in the truck access will be so low.

The important part of spacing concerns queue length - -especially back from the intersection of two major routes. Spillback from a driveway left turn storage that interferes with operation of such an intersection would adversely impact not only the public, but also the shopping center vitality. The minimum distance for a high volume driveway away from such an intersection (measured center-to-center) should be the sum of:

1. Length of the intersection left turn bay.
2. Length of taper (100 to 120 feet).
3. Length of left turn bay for shopping center.
4. 100 feet (assumed bay end setback from intersection plus driveway centers).

This calculation assumes the shopping center entrance is on the approach side to the intersection. If not, the dimension #3 is inappropriate. As pointed out in the Public Works papers[3] these criteria allow a signalized access point relatively close to the major intersection, however 2-way progression on the street can be maintained because the green portion of the signal cycle for the driveway exit is normally much less than for the cross route at the intersection.

A second point for consideration of access location from a major intersection is the queue length back from it during the red interval. While this can be calculated in theory from the Highway Capacity Manual,[10] a better method is to measure it as part of a traffic count of the approach leg. By suitable extrapolation of projected future volume (especially with comparison between actual and computed queue length based on current volume), an appropriate access point may be found in advance of the expected backup. As a final note, these deliberations will be complicated if improvements are made at the major intersection, such as addition of lanes - -especially a right turn only lane. In fact, such an addition, even if not directly involving added shopping traffic, might be justified to reduce overall impact and even allow a driveway closer to the intersection.

A valuable additional discussion of access design is given in the ITE Informational Report.[9]

Turn and Multi-Lanes

A previously noted, the main access driveways of Community and Regional type shopping centers typically warrant separate right and left turn exit lanes. If under traffic signal control, and with a significant volume of left turn exit, dual left turn lanes may be warranted to reduce required driveway green time (and hence delay to street traffic). In this case, a third, right turn lane exit lane may be needed.

Signal Control of Driveways

Extensive detail studies have been made of driveway volumes and accidents in Skokie, Illinois, a Chicago suburb. It was found that 43% of the accidents involved left turn entry from the street, while 27% involved left turn exit from the driveway (right turn accidents were 15% during entry and the same proportion during exit).[6] Evidently, when volumes justify traffic signal control, exit driveway accidents can be reduced. If left turns into the driveway are also controlled, coupled with provision of an exclusive left turn lane on the street, about two-thirds of driveway accident problems can be addressed.

Another study[11] of accidents at three regional shopping center signalized driveways found an annual average of only 0.5 left turn collisions per location. This remarkable record involved a so-called one-half signal operation along the major route (see Figure 3), where only the southbound through traffic is controlled. When practical for a site, this design represents an excellent concept, as it allows progressive signal timing for both directions of street travel, irrespective of driveway spacing. However, note that the design typically calls for a barrier median at least 18 feet wide and does not provide any control for pedestrian crossing of the major street, nor any consideration of driveways across from the shopping center.

Relative to when traffic signal control should be considered, use of warrants in the MUTCD (Manual on Uniform Traffic Control Devices) Part 4 [12] is both appropriate and most likely a legal requirement. Warrants 2 and 3, (the 4-hour and the peak hour ones), typically apply, although Condition B of Warrant 1, Interruption of Continuous Traffic, may apply for the 8-hour study period.

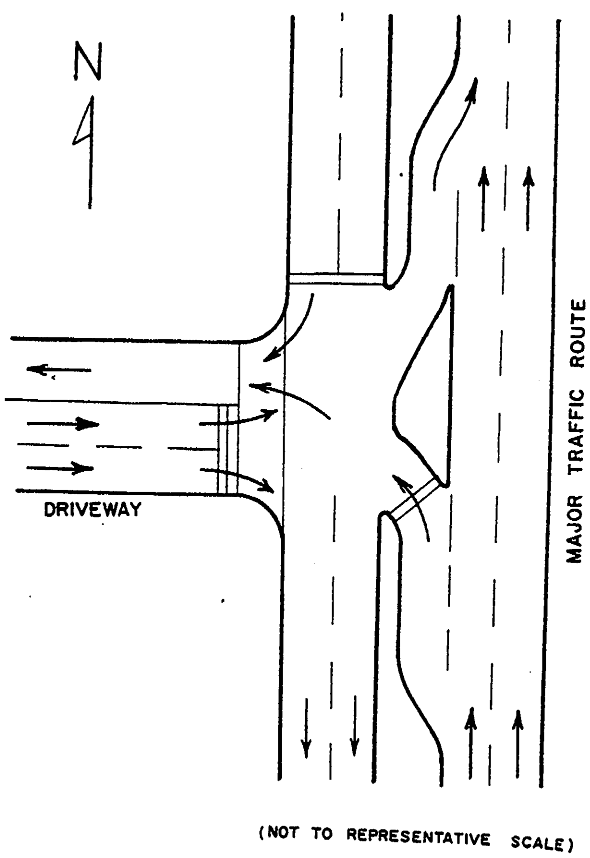

Figure 3. MAJOR ROUTE CHANNELIZATION FOR A HALF SIGNAL ACCESS POINT
(Source: Ref. 11, Figure II)

Reservoir Space

For shopping centers of the large Neighborhood type and up, primary driveways should have controlled throat channelization extending back into the site. A 'rule of thumb' is the length of curbing with no internal access to be equal in feet to the estimated peak hour left turn exit volume of vehicles; i.e., for a 100 vehicle/hour left turn volume, a 100-foot reservoir would be needed. (For a very high volume of left turn exit, with dual lanes for same, a reservoir length of about one-half the volume is indicated). For Regional shopping centers with Ring Roads, it is customary to extend the reservoir all the way from the street to the Ring Road.

Capacity and On-Street Turn Lanes

There are two capacity issues in the development of shopping centers - -at the access driveways and at the most heavily impacted public street intersections. Both should be of concern to developers and public officials, alike.

Management of left turns in and out of driveways and at intersections is usually the most critical design element - -both accident and congestion-wise. *Nearly every shopping center, from large Neighborhood and up, needs exclusive left turn bays at access points along abutting major streets.* Exceptions occur for 1-way streets and, of course, if 2-way left turn lanes are on the street. The lengths of exclusive lanes should be based on reasonable estimates of directional distribution of arriving traffic as discussed under Classification of the Development.

Warranting of left turn lanes and storage length was well developed by Harmelink, based on the two critical elements of left turning and opposing traffic volumes.[13] His warrant values are presented on Figure 4.

Provision of right turn lanes may be appropriate at driveways with:

- High volumes, such as over 150 right turning vehicles in the peak hour.
- High speed approach on the access road such as at 50 MPH or more
- Traffic signal control.

At signalized public street intersections, construction of right turn lanes is chiefly to enhance overall capacity, regardless of whether any added shopping center traffic is involved.

It also should be noted that, while capacity impact on the street system normally occurs on a weekly PM peak hour - -particularly on Friday, the driveway storage lane design needs peak on Saturday - - usually between 11:00 and 13:00 hours for all types of shopping centers.

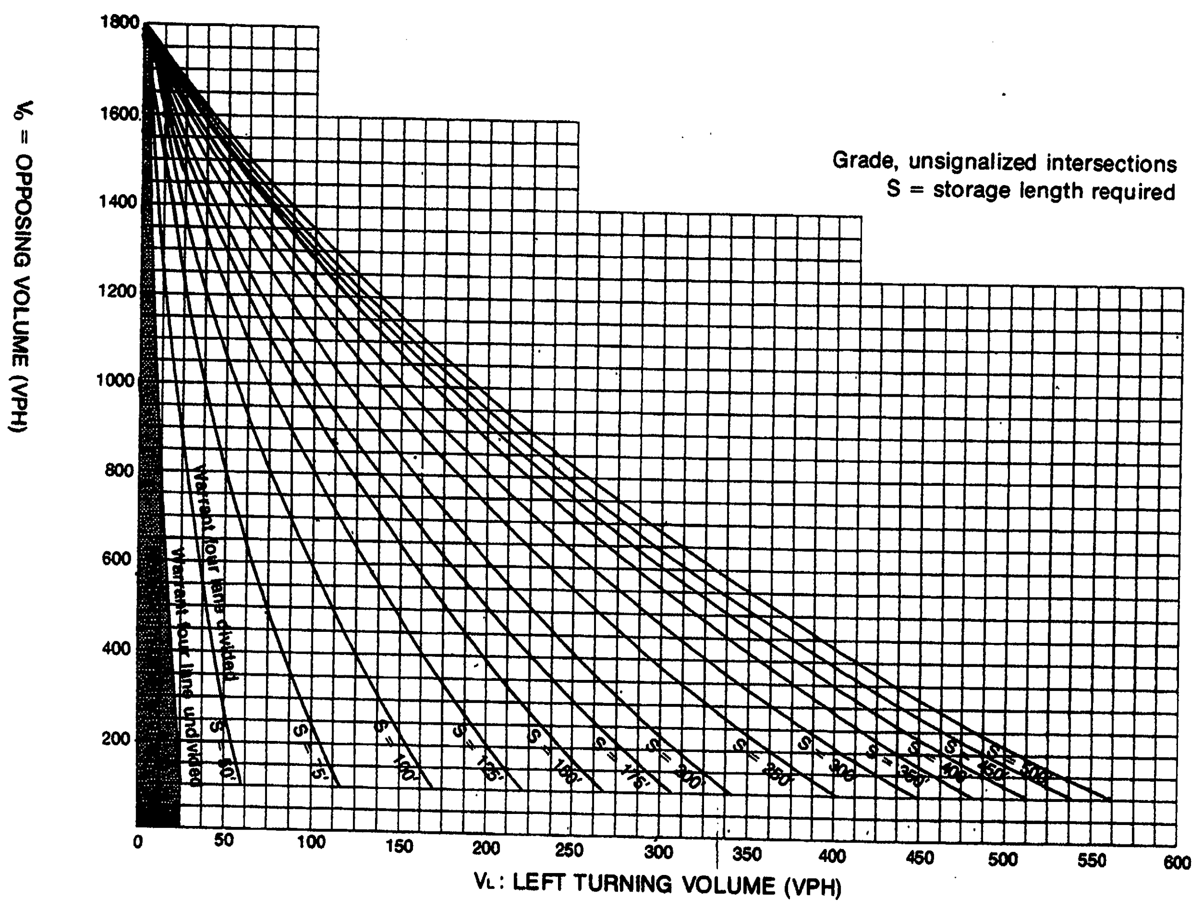

Figure 4. WARRANTS FOR LEFT-TURN STORAGE LANES ON 4-LANE, AT-GRADE, UNSIGNALIZED HIGHWAYS. THE SECTION ON GRAPH LYING BETWEEN "UNDIVIDED" AND "DIVIDED" (V_L = 25 TO 55 VPH FOR A V_O LEVEL OF 20 VPH) RELATES TO A WARRANT FOR A ONE-SPACE LENGTH AS PROVIDED BY AN ORDINARY OPENING IN A MEDIAN ABOUT 20 FEET WIDE. (Source: Ref. 13, Figure 1)

Building Frontage Roadways (BFRs)

BFRs are roadways along the frontage of retail stores - -usually separating the store from the parking area. They have been correctly described by Gern,[1] Kenig,[14] and Alroth[15] as the most critical area of vehicular-pedestrian conflict in a shopping center. Information from counts of vehicular and pedestrian BFR traffic at a free-standing grocery store, a Walmart, another Community, and at a Regional shopping center is presented in a recent paper.[16]

The primary traffic functions of these roadways are to provide customer pickup/dropoff or package pickup and for access/egress to parking aisles. This requires one lane for each direction of travel plus sufficient width for a stopped passenger vehicle. While older designs used 36 feet for these purposes, a 30-foot width has the advantage of reducing walking distance across the road. While most vehicle 'stops' along the road are on the building side, a few occur next to the parking side. Accommodation of both would require a 36-foot width, if a centerline is painted. Alternatively, the 30-foot cross-section with no centerline allows vehicular traffic to shift as needed to avoid stopped vehicles on either side.

Observance of typical shopping center BFRs will show an almost endless variety of crosswalks in use - -typically of yellow color. Observance and study of pedestrian crossing patterns will show that:

- Behavior on store exit most often involves walking down the building frontage sidewalk until at or near the aisle parked in, or

- Walking diagonally to or from the building entrance and the aisle parked in.

These characteristics strongly suggest that no policy or design criteria be set relative to painting any BFR crosswalk (excepting perhaps in extension of any separated pedestrian route between a boundary street and a main building or mall entrance). No studies have been found that a white color of crosswalks is any better than yellow, so this issue, while at variance with the MUTCD[12] seems most appropriately handled by the retailers.

Parking should, of course, be prohibited along the BFRs. The Uniform Vehicle Code defines 'parking' as "the standing of a vehicle, whether occupied or not, otherwise than temporarily for the purpose of and while actually engaged in loading or unloading property or passengers." [17] Thus, prohibition of 'parking' creates no conflict with the proper functions of a BFR.

CHAPTER 3
PARKING DESIGN

Aisle Orientation to Building

Except for a very small center, parking stalls should be serviced from aisles radiating outward from the BFRs. With 90-degree stall layout, the aisles operate 2-way and avoid the recirculation into the BFR produced by alternating 1-way aisles with the 60-degree angle parking prevalent in so many centers. This 'favorite' of certain retailers is based on greater ease of the parking maneuver as compared with the right angle stalls. However, a detailed study related to stall angle of 116 parking lots in Naperville, Illinois, found the following annual accident frequencies per 1,000 spaces:[18]

- 60 to 75-degree ... 26.5
- 90-degree 6.5
- All angles 12.1

While these findings clearly need to be supported by further study, they are sufficient to raise questions on the issue. One of the best discussions of the two primary parking angle arrangements was produced by Welch[19] and summarized as follows in Parking Principles:[20]

> "Much of the alleged difficulty with 90-degree parking has stemmed from inadequate aisle dimensions. Where proper measurements are used, a smooth and efficient operation can be achieved. As Welch has stressed, there are at least eight advantages in 90-degree layout for shopping center parking. Half of these advantages deal with the greater convenience to the parker, and the others relate to safety and operating efficiency. For example, at parking angles of less than 90-degrees, the aisles are normally 1-way. Sometimes this is desirable, but regimentation of traffic flow within a parking facility should be minimized. Furthermore, the narrower 1-way aisles do not provide room to pass a standing or waiting vehicle. The 1-way aisles require drivers to circulate at least once next to the principal buildings during the pattern of entry and exit. This increases conflict with pedestrians in the lot and causes unnecessary congestion. It also requires driving greater distances within the aisles past other parked vehicles and increases the accident potential. Such problems are reduced with 90-degree parking. Other advantages, as compared with lesser parking angles, include better sight distance at aisle intersections, fewer aisles (hence easier locating of a parked vehicle), and better approach vistas of the shopping center buildings because of the wider aisles."

For further discussion see Stall Widths and Angles.

For both architects and engineers, it is perhaps appropriate here to summarize the relation between operation and design. In Parking Principles[20] the following (slightly revised) observations were made:

> "The operation of a parking facility is greatly influenced by its design. The operational elements and their associated design features may be identified in successive steps as follows:

1. Vehicular access from the street system (entry driveway);
2. Search for a parking stall (circulation and/or access aisles);
3. Maneuver space to enter the stall (access aisle);
4. Sufficient stall size to accommodate the vehicle's length and width *plus* space to open car doors wide enough to enter and leave vehicle (assumes some space in adjacent stall);
5. Pedestrian access to and from the facility boundary (usually via the aisles);
6. Maneuver space to exit from the parking stall (access aisles);
7. Routing to leave the facility (access and circulation aisles); and
8. Vehicular egress to the street system (exit driveway).

The simplest form of off-street parking is the single stall at a home. Assuming a straight driveway, steps 1 and 8 use the same lane and curb cut opening. Steps 2 and 7 are rudimentary. Step 6 usually involves backing out into the public street or alley, as part of 7 and 8. Herein lies the essential difference between low-volume parking and what generally should be practiced in facilities designed to handle more than two or three cars. Except along alleys, the larger lots should have all parking and unparking maneuvers contained off-street. Frequent backing of cars across sidewalks and into public streets increases congestion and creates hazards."

End Island Length

Properly designed, raised curb islands at the end of parking rows may have the following advantages:

- Limit encroachment into crosswise circulation aisles, BFRs and ring roads.
- Open up sight distance at these intersections.
- Provide a somewhat protected area for sign posts and light poles without need for raised concrete bases.
- Provide a small landscaping area for grass, ground cover, low growing height bushes and suitable trees. (Also see the Landscaping section for limits).

The value of end islands in a regional center was confirmed by Nunez and Parsonson[(21)] in a study of accidents in five Atlanta, Georgia regional shopping centers. One with no end islands (parking allowed right up to the edge of crossroads) averaged 43 accidents per Christmas season versus an average of only 12 per season for the three similar size centers with end islands that they studied. About two-thirds of the accidents in the center with no end islands were of right angle type.

Further data of importance from this seminal study was finding typical 85th percentile approach speeds of 25 MPH and a need for sight distance of about 220 feet for a 2-lane crossroad, and up to 260 feet for four lanes.

While arguably less effective than raised islands, painted types may be effective for many applications to Community and Regional centers. Small Neighborhood centers having only a few hundred parking spaces likely require no end islands, since cross aisles are short, speeds are correspondingly low, and required sight distance minimal.

The dimensions to form a properly designed end island include sufficient <u>depth</u> to open sight distance and a limitation of <u>length</u> to meet a right turn radius swept path. Far too many designs place the end of the island at the end of the parking stall, making it nearly impossible for a vehicle approaching from the left to turn right into an aisle, if another vehicle is standing in the aisle waiting to exit. The design shown in Figure 5 from the ITE Guidelines for Parking Facility Location and Design[22] avoids this problem.

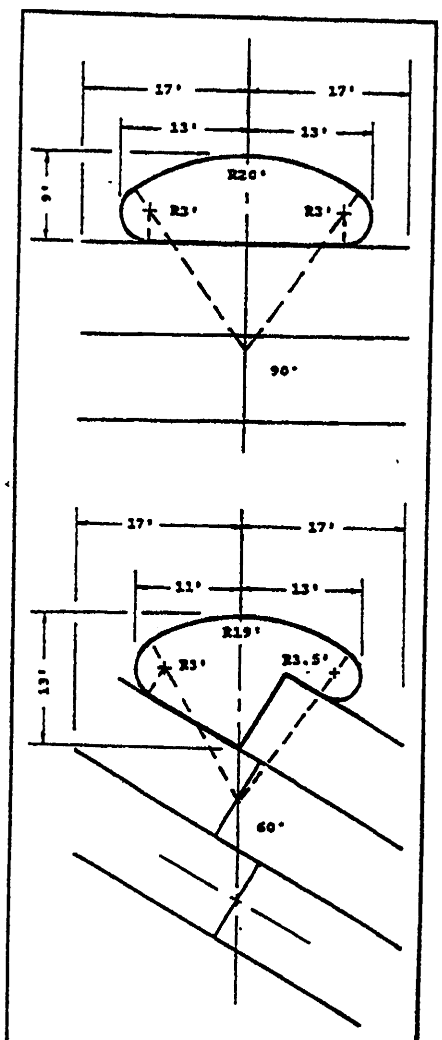

FIGURE 5. EXAMPLES OF END ISLANDS FOR LARGE-CAR STALLS
Source: Ref. 22, Fig. 7

Wheelstops and Other Vehicle Limits

As far back as about 1967 the National Safety Council warned that wheelstops "may cause pedestrians to trip and fall."[(23)] This same concern has been expressed by over a dozen subsequent publications. For a listing, see Ref. 24. Insurance safety engineer Wm English has flatly stated "The presence of wheelstops in new parking lots is *prima facie* evidence of negligent design."[(25)] The problem is directly addressed in an ASTM Specification.[(26)] In paragraph 9, they say:

"9.1 Parking lots should be designed to avoid the use of wheel stops.

9.2 Wheel stops shall not be placed in pedestrian walkways or foreseeable pedestrian paths.

9.3 Wheel stops shall be in contrast with their surroundings.

9.4 Wheel stops shall be no longer than 6 ft (1.83 m) and shall be placed in the center of parking stalls. The minimum width of pedestrian passage between wheel stops shall be 3 ft (0.91 m).

9.5 The top of wheel stops shall not exceed 6.5 in. (1.65 mm) in height above the parking lot surface.

9.6 Adequate illumination shall be maintained at wheel stops as governed by the requirements of local codes and ordinances or, in their absence, by the recommendations set forth by the Illuminating Engineering Society of North America (IES-Application and Reference Volumes).

9.7 Bollards, not less than 3 ft 6 in. (1.07 m) height, may be placed in the center of parking stalls as an alternative to wheel stops. Bollards should be appropriately marked to enhance visibility in accordance with ANSI-Z535.1."

The key element here is 'foreseeable pedestrian path'. Wheelstops next to a fence, wall or guardrail, where pedestrians cannot walk, are obviously not a trip hazard. Yet their use in foreseeable paths is widespread. A survey of over 1,200 lots in 31 cities of 9 states found one-third had wheelstops placed in direct pedestrian paths, with Miami, Florida being the worst, having these obstructions in about two-thirds of the lots surveyed.[(24)]

It may, of course, be necessary to provide some level of protection for building fronts or canopy columns. Placement of a single bollard in front of a parking stall, as advocated by the ASTM, is effective only if the parker drives within the stall limits. However, numerous cases exist where drivers have driven on the stall line and would therefore readily pass between bollards located solely in the center of stalls. A more complete listing of alternate protection methods is contained in Ref. 24 and quoted below:

"**Protection of Building Front and/or Canopy Columns**

1. Some form of restraining device is needed. Types used include:
   a. Raised walk.
   b. Closely spaced posts about 4 feet on center
   c. Wheelstop
   d. Highway guardrail.
2. Raised walk is best.
   a. People expect to step up or down at building entrance and along building walk.
   b. Keeps snow melt from lot plowing and droppings from vehicles off the walk.

c. Less maintenance than wheelstop.
d. Less hazardous than wheelstop.
    1) Only one step (up or down) versus step up, over wheelstop, then down.
    2) Wheelstop drain area can catch toe.
3. Posts are less desirable than raised walk.
    a. Drivers shy away from striking, thus sticking farther into access aisle.
    b. Does not prevent snow melt problems.
    c. Interferes with snow plowing.
    d. Lacks flexibility to easily relocate if parking stall widths are changed in the future.
4. Wheelstops alone are less desirable than raised walk.
    a. Can readily be knocked loose from pins by vehicles or snow plows.
    b. Most likely to cause trips especially if not centered in parking stalls (stick out into walking area along stall lines between parked cars).
    c. Interferes with snow plowing.
    d. Traps blowing debris.
5. Wheelstops should not be used in conjunction with raised walks:
    a. Increases foot movement when crossing blocks (only up or down at raised walk or curb versus up and down over wheelstops).
    b. May be particularly unexpected.
    c. Have other disadvantages as listed in Number 4, above.
6. Guardrails are less desirable than raised walk:
    a. Prevents pedestrian access to store front walk, requiring car occupants to walk in access aisle.
    b. Blocks access to trunk loading, for cars backed up toward store."

<u>Stall Widths and Angles, Aisle Widths</u>

It is well-known that parking stall and aisle width are related, as are stall angles and aisle widths. Narrow aisles, for any parking angle, may be accepted by use of wider stalls and vice versa. Many sources list dimensions for varying stall angles. Those in Parking Principles[20] were developed by field layout of various combinations, with testors driving full size, unfamiliar vehicles to simulate less-skilled drivers. However, the handling characteristics as well as size have changed since the 1960s. Updated figures in the ITE Guidelines[22] are quite similar to those developed in 2001 by Smith for Architectural Graphics Standards.[28]

It is possible to lay out parking at an angle, such as 60-degrees along <u>both sides</u> of a 2-way aisle, however it has none of the advantages of a 90-degree layout and all the disadvantages of a 60-degree angle. The ITE document developed a stall width class, reproduced in Table 5.

Table 5. Stall width Classification

		Typical Turnover			
Class	Width(ft)*	Low	Medium	High	Typical Uses
A	9.00			X	Retail customers, banks, fast foods, other very high turnover
B	8.75		X	X	Retail customers, visitors
C	8,.50	X	X		Visitors, office employees, residential, airport, hospitals
D	8.25		X		Industrial, commuter, university

*Large-size vehicle, measured at right angles to stall.
Source: Ref. 22, Table 1.

For large-size cars, guideline dimensions are given in Table 6. However, footnote 'd' generally no longer applies, since many cars now have fiber 'dams' under the front that drag on curbs over about 4 inches high and hence inhibit drivers from fully pulling forward until their tires contact a curb.(29)

Table 6. Large Size Parking Layout Dimension Guidelines

						Modules	
Parking Class[b]	S_w Basic Stall Width[c] (ft)	*WP* Stall Width Parallel to Aisle (ft)	VP_w Stall Depth to Wall (ft)	VP_i Stall Depth to Interlock[d] (ft)	*AW* Aisle Width[e,f] (ft)	W_2 Wall to Wall[f] (ft)	W_4 Interlock to Interlock[d,f] (ft)
	Two-Way Aisle—90 Degrees						
A	9.00	9.00	17.5	17.5	26.0	61.0	61.0
B	8.75	8.75					
C	8.50	8.50					
D	8.25	8.25					
	Two-Way Aisle—60 Degrees						
A	9.00	10.4	18.0	16.5	26.0	62.0	59.0
B	8.75	10.1					
C	8.50	9.8					
D	8.25	9.5					
	One-Way Aisle—75 Degrees						
A	9.00	9.3	18.5	17.5	22.0	59.0	57.0
B	8.75	9.0					
C	8.50	8.8					
D	8.25	8.5					
	One-Way Aisle—60 Degrees						
A	9.00	10.4	18.0	16.5	18.0	54.0	51.0
B	8.75	10.1					
C	8.50	9.8					
D	8.25	9.5					
	One-Way Aisle—45 Degrees						
A	9.00	12.7	16.5	14.5	15.0	48.0	44.0
B	8.75	12.4					
C	8.50	12.0					
D	8.25	11.7					

NOTES: These dimensions are subject to slight reductions by local agencies under high-cost conditions (such as garages) or slight increases in areas subject to special needs (such as extensive snowfall).
[c]Measured at right angles to stall line.
[d]May also apply to boundary curb where bumper overhang is allowed.
[e]To vehicle corner.
[f]Rounded to nearest foot.

Source: Ref. 22, Table 2.

The efficiency of parking layout, minimum or unit area required per space for stall plus maneuver obviously should be of interest to both the developer and the architect. A study by the City of Los Angeles, using double-loaded aisles for 9 x 18 foot stalls at angles of 30 to 90-degrees found the following efficiencies:[27]

- 30-degree 66%
- 45-degree 79%
- 60-degree 85%
- 90-degree 100%

Of course, the most efficient layout angle for any specific site depends on the size and especially the shape. This is of most importance in the small Neighborhood centers, since most Community and Regional developments have tracts large enough to flexibly employ any parking angle.

Dimensions and usage of stalls for small cars are given in the next section.

Small Car Spaces

While common in other countries, perhaps largely due to high fuel prices, small car use has varied in the U.S. Whether the greatly increased fuel economy standards announced in 2012 will substantially increase the percentage of small vehicles, increase hybrids or lead to dramatic improvements in engine performance cannot be foretold. While there will always be some proportion of 'small' vehicles, current figures suggest not more than about 20 percent of parking stalls be of reduced size, *if any at all.*[28]

If small car spaces are used, guidelines from the ITE document[22] are reproduced in Table 7 (note that the same admonition re footnote 'd' for Table 6 also applies).

Table 7. Small-Size Parking Layout Dimension Guidelines

Parking Class[b]	*S_w Basic Stall Width[c] (ft)*	*WP Stall Width Parallel to Aisle (ft)*	*VP_w Stall Depth to Wall (ft)*	*VP_i Stall Depth to Interlock[d] (ft)*	*AW Aisle Width[e,f] (ft)*	*Modules: W_2 Wall to Wall[f] (ft)*	*Modules: W_4 Interlock to Interlock[d,f] (ft)*
	Two-Way Aisle—90 Degrees						
A/B	8.0	8.0	15.0	15.0	21.0	51.0	51.0
C/D	7.5	7.5					
	Two-Way Aisle—60 Degrees						
A/B	8.0	9.3	15.4	14.0	21.0	52.0	50.0
C/D	7.5	8.7					
	One-Way Aisle—75 Degrees						
A/B	8.0	8.3	16.0	15.1	17.0	49.0	47.0
C/D	7.5	7.8					
	One-Way Aisle—60 Degrees						
A/B	8.0	9.3	15.4	14.0	15.0	46.0	43.0
C/D	7.5	8.7					
	One-Way Aisles—45 Degrees						
A/B	8.0	11.3	14.2	12.3	13.0	42.0	38.0
C/D	7.5	10.6					

[c] Measured at right angles to stall line.
[d] May also apply to boundary curb where bumper overhang is allowed.
[e] To vehicle corner.
[f] Rounded to nearest foot.

Source: Ref. 22, Table 3.

Colors of Markings (Also see Chapter 4 Roadway Striping)

In general, parking stall markings should be white. Exceptions occur for markings on PCC (Portland Cement Concrete) where yellow gives most contrast and in some outlying portions of Regional Shopping Center lots designated for employees, only.

Turn lane lines, arrows and words should all be white, as designated in the MUTCD[12] and likely legally required by state adopters of the Manual, since the Federal Highway Administration decreed that roadways on private property that are open to the public must comply in this respect to the Manual (but that parking areas were exempt).

Hazard markings and some 'no parking' along curbs are yellow as are centerlines of 4-lane ring roads. Red also may be used on curbs to designate 'no parking', however supplemental signs are highly desirable. This is especially important in northern climates where snow can cover curb markings.

One Versus Two-Line Stall Markings

For many years some engineers, architects and retailers opined that drivers parked more properly in their stalls with two-line (hairpin) markings on each side. Need for research was noted by the Highway Research Board Parking Committee in 1971. In 1993, 6,800 occupied parking stalls at 14 sites in 3 states were observed relative to encroachment on or over the stall lines.[30] Both 60-degree and 90-degree layouts were checked for several land uses. Little difference in the findings appeared between shopping centers and other uses.

Surprising perhaps for some persons, the percents of encroachments on or over the stall marking centerlines were all slightly greater for the hairpin type (however, not so much as to preclude their use if an owner wishes to bear the added expense).

Another survey of 10,000 parkers at 25 garages of varied use was reported by Mack for six Colorado cities.[31] Findings included:

- Hairpin striping cost 2.3 times that for single line.
- Hairpin striping use was 28% versus 72% for single line.
- 90-degree parking was used 61.1% versus 38.9% angle.
- 8.5-foot wide stalls were used 71% versus 26% 9-foot width.

Lighting

There are several reasons for lighting parking and driving/walking areas of shopping centers:

- Vehicular safety.
- Pedestrian safety.
- Personal security.
- Promote retailer interests.

Vehicular safety issues involve sufficient illumination to identify hazards on the vehicle path (such as potholes, ice patches, raised objects and - -of prime concern- - pedestrians). Pedestrian safety has to do with minimizing trip-and-fall on curbing, road or sidewalk pavement defects, stairs in garages, etc.

The Naperville, Illinois[18] and other Chicago suburb parking accident studies found only about six percent involved striking fixed objects and just one percent to involve pedestrians. This conflicts with public streets, where the primary benefit of lighting has been found to be reduction in pedestrian or bicycle and fixed object accidents at night.[31] None of these studies gathered data on pedestrian trip-and-fall mishaps. However, a paper by Monahan[33] as reported in Ref. 34, below, covered a major study of claims in commercial parking facilities and found:

- Slip or trip-and-fall, 75% of total claims, and
- Slightly over 50% of costs paid out
- Vehicle damage, 9%
- Personal assault, 7%

Perhaps the most important reason for lighting parking areas, roadways and walkways is the *personal security* issue. In addition to conventional crimes (such as auto theft, vandalism and personal assaults), the issue of terrorism in the giant consumer sector (read 'malls') has risen since the World Trade Center attacks.

Relative to retailer interest in lighting, attractiveness, concern for employee personal safety and legal liability are generally the major issues.

Illumination is expressed as 'lumens per square foot', usually in a hortizonal plane (the pavement) for safety measures, and in a vertical plane for facial awareness in personal security issues. There are three measures for horizontal illumination on the pavement; minimum, maximum and average. The *minimum* is that required by an average person with normal eyesight to see a hazard at a sufficient distance to identify, react and avoid it. An older vehicle driver requires about 1.8 seconds on average to react at night.[34] If driving at 25 MPH on a Regional center ring road, for example, this means about 66 feet before the brakes are applied (plus 83 feet of skid if AASHTO side friction factors are used[7] or 28 feet if a more likely factor is used). The *maximum* is generally found on the road directly beneath the luminaire.

A pedestrian walks about 4 feet per second[12] with a reaction time of about one second. A perception distance of about 7 to 10 feet is recommended in Annex D of the IES Recommended Practice for Parking Facilities.[35] However, relative to *security*, facial awareness but not necessarily 'recognition' should be available at least 30 feet away.[36]

A summary of IESNA recommendations for Parking Lot Lighting[35] is given in Table 8.

Table 8. Recommended Maintained Illumination Values for Parking Lots

	Basic Value	Enhanced Security
Minimum horizontal footcandles on surface	0.2	0.5
Uniformity Ratio, Maximum to Minimum	20:1	15:1
Minimum vertical footcandles at 5-ft above surface	0.1	0.25

Source: Ref. 35, Table 1.

In addition to the recommended values, there are several important issues to address. *Maintained* means the condition of lighting just before lamps are replaced and glassware/reflectors are cleaned, when available lighting may be only a fraction of the initial design values. To best maintain lighting a group replacement plan for lamps at about 75 to 80% of rated lamp life is preferred.[35] It is most economical to have a cleaning cycle coincide with such a replacement schedule. Determination of 'enhanced security' needs is site-specific and related to frequency of security patrols as well as neighborhood and attractiveness issues.

Because walking within a garage is more confined than in an open area, they need much better lighting than parking lots. Table 9 gives recommended values for various geometric elements particular to garages.

Table 9. Recommended Maintained Illuminance Values for Parking Garages

Area	Minimum Horizontal Footcandles on Floor	Minimum Vertical Footcandles at 5 ft. Above Floor
Basic	1.0	0.5
Ramps:		
Day	2.0	1.0
Night	1.0	0.5
Entrance Areas:		
Day	50	25
Night	1.0	0.5
Stairways	2.0	1.0

Source: Ref. 35, Table 2.

NOTE: A maximum to minimum uniformity ratio of 10:1 is recommended for all areas except stairways.

The foregoing is only a brief summary of lighting issues. Numerous other elements should be considered such as the best lamp and luminaire types, color rendition, emergency lighting, glare, pole location position in lots and top levels of garages, provision for CCTV, and use of daylight in garage designs. See Ref. 35 for such detail.

Landscaping

Trees, shrubs and ground covers are primarily issues of esthetics for parking lots, to breakup a 'sea of asphalt' vista. Some cities even specify elements such as how many parking spaces can form a row until plantings are inserted or require a certain percent of lot area to be landscaped. In any event, there are areas of lots where specific types of landscaping are appropriate. Table 10 lists several:

Table 10. Landscaping Locations

		Acceptability by Type				
		Bushes		Trees		
SITE FACTORS	Groundcover	2-ft max. height	Over 2-ft Height	8-ft clear lower	Any	Flowering Plants
Near Driveways	x	x		x		x
End Islands	x	x		x		
Diverter Islands	x	x		x		x
Perimeter Strips	x		x		x	x

Source: Adopted from Ref. 37, Chapter 9.
NOTE: For strips within 3 feet of parking stalls, use only groundcover.

Drainage and Maintenance

Depressions in the pavement (particularly asphaltic concrete) are commonly referred to as "birdbaths". In northern climates water can accumulate in depths as shallow as one-fourth inch due to rain or snow melt, then freeze to form a slip-and-fall hazard. As a practical matter, it is impossible to avoid all such depressions, however a one percent drainage slope for asphaltic lots and 0.5 percent for Portland Cement Concrete is recommended by one source(20) with two percent for asphalt by another source.(37)

Maintenance of parking lots involves not only periodic routine sweeping and snow plowing in northern climates, but also surface upkeep. For asphaltic lots this means sealing every few years and patch/resurfacing at longer intervals. The frequency of such work depends on both climate and quality of construction - -particularly the pavement base . In all cases, full-surface treatment requires re-striping, which is likely to be needed anyhow. Between such 'major' projects, patching of potholes is essential to avoid trip or slip-and-fall accidents as well as vehicular damage. Other maintenance items for lots include:

- Signs
- Lighting
- Drain cleaning
- Vegetation trimming

Garage maintenance requires routine inspection to note areas of corrosion or water leakage. Elements identified in Dimensions of Parking include:[37]

"• Top surfaces of all floors and bottoms of parking floors
• Columns
• Beams
• Guardrails and handrails (to verify that they are rigid and safe)
• Stairways
• Walls
• Connections and bearing pads in a precast concrete system; and
• Wheelstops "

Housekeeping needs, maintenance of lighting and of mechanical equipment such as elevators are obvious components of the system.

For garages with wire cable vehicle arresters, such as along outer edges of the structure, it is essential that a safe restraining capacity be available. It was reported that using hydraulic rams for multiple barrier force verification would have taken a week or more for a City of Chicago garage. However, a NDT (Non-Destructive Test) was found that completed the work in two hours.[38]

Legal Liability

A 10-year tabulation of accident claims (mostly in shopping centers) investigated by one engineer found the following:[39]

Table 11. Parking Facility Accident Claims

TYPE	LOCATION ON SITE			
	Wheelstop or Curb	in BFR	in Site	Other (in bldg., etc)
Vehicle/pedestrian	1	15	6	
Vehicle/bldg or other/fixed object		4	2	
Vehicle/vehicle			5	1
Subtotal	1	19	13	1
Slip/Trip-and-Fall	17	25	18	37
TOTAL ALL	18	44	31	38

Source: Ref. 39.

Two items are of particular significance in Table 9. First is the preponderance of pedestrian accidents in the BFR. Second is the fact that about 60 of the 93, or 65% of the claims were for slip-and-fall - -comparable to the 75% finding by Monahan.[33]

Some years ago the National Parking Association reprinted data from the American Law Reports on Parking Lot Liability Claims.[40] A tabulation of the 14 highest number of case subjects is given in Table 12, based upon an attempt to classify them from the descriptions given.[39] A wide variety of miscellaneous subjects (about one-third of the total) limit the usefulness, however it does show the extent of some conditions that generated claims. The low proportion of wheelstop cases may be the result of out-of-court settlements, when liability is so clear.

Table 12. 14 Highest Parking Lot Liability Claim Case Subjects

SUBJECT	NUMBER OF CASES		
	DAY	NIGHT	TOTAL
Misc. objects and walls	24	11	35
Miscellaneous	22	10	32
Depression and walls	13	14	27
Wheelstops	14	12	26
Lighting	- -	16	16
Driveways	10	1	11
Walk route away from lot	6	3	9
Adjacent public walk	8	- -	8
Vehicle collision with object	5	2	7
Oily material	7	- -	7
Low chain	3	3	6
Steps	3	2	5
Median island	3	2	5
Slope	5	- -	5
TOTALS	123	76 (38%)	199

Source: Ref. 40.

CHAPTER 4
OTHER SITE ELEMENTS

Pedestrian and Bike Access

The proportion of customers arriving at a shopping center by walking or bicycle is related to the type and size of the center as well as the proximity of residential development. No special provisions are likely needed for either Neighborhood or Community centers, since they can use the relatively short parking access aisles the same as parkers do. A Regional center with nearby homes and/or apartments is a different matter. Access usually occurs at driveways connecting to the ring road, which should have sidewalks. From this point on, however, two general routings are possible. One is directly across to the diverter island (see Ring Road section), hence laterally to aline with a parking aisle. Use of an aisle for external walk-ins or bicyclists is not recommended for the long aisles because (unlike parkers) they may not be as alert to cars backing out of stalls. A preferred method is routing to a dedicated walk along a nearby roadway (if any) connecting between the ring road and the BFR or along a curbed and landscaped 'finger' separating two parking modules. Such a walk can be shared with bicycles. An 8-foot width will usually suffice, centered in a 14-foot strip if only ground cover is used on each side. With trees, a 20-foot strip is recommended.

A marked crosswalk on the ring road is recommended with advance warning unless protected by a Stop sign at the driveway/ring road intersection. In fact, an isolated, non-controlled crosswalk on a ring road, including those at an outlot theater where some of their parking might be across the road, may warrant advance flashers or a Pedestrian Hybrid Beacon (see MUTCD)[12] An excellent passive option is a raised 'table', however, use of the MUTCD design of a 6-foot rise on each side of a 10-foot table has met with complaints. A recommended design (used in the BFR of Phoenix Sky Harbor Airport, for example) is a 12-foot rise on each side of a 12-foot table.

As noted in the BFR section, a marked crosswalk or speed table across this road should be provided if in extension of a dedicated walk as described above, but advance signing is not needed because the BFR is rife with pedestrians all along it. A few bicycle racks at the entrances to a Regional mall should be installed, especially if located at the extension of a dedicated walk.

Special care should be exercised to ensure adequate *sight distance* at all dedicated pedestrian crossings of roadways. The following site planning guidelines also should be considered:

- Primary walkways should be established adjacent to significant buildings for major pedestrian movements and secondary walkways should be established to facilitate minor pedestrian movement between service areas and buildings. All walkways should be provided with adequate lighting levels and pedestrian amenities as required (benches, fountains, trash cans, etc).

- The width of primary walkways is dependent on expected use and landscape requirements, however, primary walkways should be a minimum of six to eight feet wide and secondary walkways should be a minimum of four feet wide.

- Walkway surfaces should be non-skid surfaces and have cross slopes of one to two percent.

- Steps should be avoided whenever possible, however, the minimum clear width for exterior landings should be 6 feet and the maximum rise between landings should be 4 feet. Riser heights for exterior steps should be four to seven inches while tread widths should be eleven-inch minimal. Handrails should be provided on both sides and in the center if steps are five feet or more wide.

- Ramps must be provided to facilitate handicap movement to and from buildings and parking areas in combination with walkways and steps according to Americans With Disability Act standards. See local Building Code.

Provisions for Truck Load/Unload

At Neighborhood and Community type centers, truck loading and unloading normally uses docks located behind the stores. Some customer pickup/dropoff may also occur here - -particularly of larger merchandise. An outer row of employee parking is sometimes available although special personal security issues must be considered.

Routing is provided to and from such rear areas, usually at each end of a row of buildings. Depending on site orientation to the public road system, driveways and aisles are designed primarily for truck use, but often also offer a row of overflow customer parking. Conflict with customers seldom occurs due to service hours and the very low volume of trucks. Appropriate pavement design must be used along truck routes and in the loading areas.

Following is a list of AASHTO service vehicles typically used to assess the maneuverability throughout a shopping center:[7]

- Single Unit 30-foot Truck - - Overall length of 30 feet.

- WB-12 Truck - - Overall length from front overhang to rear overhang, 45 feet or greater

- WB-15 Truck - - Overall length from front overhang to rear overhang, 55 feet.

- WB-19 Truck - - Overall length from front overhang to rear overhang, 69 feet.

The basic route from the external roadway to each truck dock should be laid out and each route checked with truck turning templates (see Refs. 7 and 42). The following information applies to schedules:

- Anchor stores typically have their own loading docks and scheduling can occur throughout the day. Stores will typically schedule deliveries during the regular work week and during the morning hours. Service vehicles accessing anchor stores will range from the largest to the smallest with a majority of the vehicles within the 55 to 69-foot range.

- Produce stores will typically have between three and five deliveries per week and they typically occur during the morning hours. Single unit 30 and 40-foot trucks are typically used.

- Mall stores will have on an average five to seven deliveries per week and are serviced by single unit 30-foot trucks. They are typically serviced through a mall corridor at a general loading area.

- Restaurants will typically schedule their deliveries during the morning hours and will have on average two to three deliveries per day. Service vehicles will range from 30 to 67-foot trucks.

Loading docks should be designed for the largest vehicle anticipated to access the area. When determining the dock location, sight lines must be considered. Ideally, service vehicles should maneuver over the truck driver's left shoulder. This will allow the driver to see from the seat to the loading dock bay. If a driver were to maneuver over the right shoulder, they would have to maneuver the truck through the side rear view mirror. This will typically leave the driver open to many blind spots and make the maneuver into the loading docks more difficult.

Load/unload facilities for Regional malls surrounded by parking fields typically use truck 'courts' or dedicated ramps down to underground docks. Otherwise, routing principles are similar to those for smaller centers. The location of truck courts is site specific to anchor and mall stores.

Speed Control

Until the day arrives (if ever) when vehicle speeds are externally controlled, some of their movements will be considered by customers and site managers as 'too fast' - -usually but not always without good reason. Unfortunately, speed 'limit' signs, as well as other signs, will be obeyed only "if drivers clearly perceive a need to do so." [12] When shopping center managers post absurdly low speed limits, drivers treat them with the contempt they deserve, just as they do on public streets. The use of frequent Stop signs along roads with shopping centers is not only annoying to customers and prone to encourage disobedience, but also *a direct violation of the MUTCD provision on sites open to public travel.*[12]

Speed bumps are commonly used, without consideration of the ASTM Standard[26] which says:

"8.1 Design to avoid the use of speed bumps.
8.2 All speed bumps which are in foreseeable pedestrian paths should comply with 5.2 (walkway changes in level).
8.3 Existing speed bumps, that do not conform to 5.2, shall be clearly marked with safety color coding to contrast with surroundings in accordance with ANSI Z535.1. Painted speed bumps shall be slip resistant. Pedestrian CAUTION signs are recommended."

Effective speed control can usually be attained by use of the following measures:

- Reasonable postings (such as 30 to 35 MPH on ring roads).

- Avoidance of long, straight sections of roads - - particularly BFR- - by use of curvilinear alinements designed in the 30 MPH range and perhaps with periodic discontinuity.

- Provision of occasional speed tables, especially at primary pedestrian crossings.

Avoidance of Public Travel Cut-through

Alinement of main shopping center driveways with intersecting cross streets is desirable, provided the driveway terminates within the center and does not run directly across to another street. Cut-through traffic can always be expected to move faster than shopper traffic within the center and hence increase potential hazard.

Connector Roads

Separate connector roads, not serving adjacent parking rows, are most frequently found in Regional type centers, and as the term implies, connect the ring road to the BFR. Cross aisles are sometimes used to break up long parking modules in both Community and Regional shopping centers. In both cases, a 2-lane width such as 30 feet is common, and their use is site-specific.

Ring Roads and Out Parcel Access

This type of road, primarily found in Regional centers, but also in elongated large Community centers, has several functions:

- Transfer traffic from the street access driveways around the center to the various anchor stores and thus reduce use of the BFR for this purpose.

- Provide internal access to out-lots so that they usually require no additional driveways to the street.

- Separate the primary parking field from overflow lots needed only for seasonal events.

The key features of a ring road are barrier-curbed diverter islands opposite the driveways to create 'T' intersections, continuity around the center, and adequate width (2 to 4 or 5 lanes) for the expected traffic and type of control at the driveways. There are no 'rules' for diverter island length, other than at least two parking modules each side of the driveway projected centerline. The depth of the island should be sufficient to open clear sight distance at each end, and also aline with parking access aisles. A value of 30 feet will even allow a row of parking on the mall side of the island, if ever needed for added parking supply in the future. It also provides an appropriate turning radius at the ends. In the interim, appropriate landscaping so as to retain clear sight distance is esthetically pleasing. A discussion of alternate traffic control and geometric design of ring road/access driveway intersections is given in Ref. 41. A caution must be inserted here. Frequent Stop signs facing the Ring Road at driveway connections (such as at the Phoenix, Arizona Paradise Valley Mall) may so encumber the route as to discourage its use in preference to the BFR.

Parking should never be located along ring roads so that vehicles would be required to back into it and, as previously discussed under the End Island section, these should always be provided where parking access aisles intersect the ring road. Raised curb islands are preferred, although painted ones at alternating aisles (Houston, Texas Baybrook Mall) and even all-painted (Fargo, North Dakota West Acres) have been successfully used.

Transit Accommodation

This is a feature of Regional centers, which may involve both local buses and tourist types. A common objective of public land use planning and transit agencies is to increase the quality and efficiency of public transportation facilities to reduce dependence on single occupancy vehicles. Approximately 20 percent of the parking demand in a Regional center at any one time is made up of employee vehicles. Provision of adequate transit service is therefore of direct value to the developer in terms of parking supply as well as to the employees. The patronage potential of transit is significant. If a 5 to 10 percent transit mode split to the Regional center could be achieved, the resulting travel changes would be:

- 2,000 to 4,000 transit trips per day for a 1,000,000 square foot center.
- A reduction of 1,200 to 2,400 automobile trips per day.
- A reduction of 250-450 parking spaces, and
- An increase in off-peak transit trips - -a distinct advantage for transit providers.

While increased transit use provides obvious land use, environmental, and societal benefits, the routing of transit service onto the shopping center traffic system needs to be carefully considered to avoid conflicts for both the shopping center operator and for the transit provider. For that reason, it is important to estimate the nature and intensity of transit use early in the planning process in order to balance the benefits of such service with the potential degradation of on-site traffic and pedestrian flow. Issues influencing the potential for transit use at a shopping center include:

- Setting of the center (urban versus suburban)
- Available transit modes
- Public transit planning and initiatives
- Shopping center tenant mix (retail, dining, entertainment)
- Customer and employee travel modes
- Geographic comprehensiveness of transit system
- Perceived quality of transit system
- Tourist market
- Park-and-ride potential

Transit routes should use main circulation roads except for immediate access to store fronts. Stops are usually most beneficial for transit patrons if located near major entrances to the shopping center. Where such entrances are not well defined, stops can be placed in locations most convenient to focal points of activity or concentrations of business. Layover areas are needed for local buses to meet headways and this may best be done with a transit 'center'.

Information on bus lengths is available for local buses from the transit agency and for tourist buses from the AASHTO.(7) The latter source also provides geometric design dimensions for various types. Evidently, roadways with bus use must have appropriate turning radii, width and pavement strength for the expected operation.

Garages

When used in Regional centers, garages are typically located on the store side of the BFR, giving direct access to anchor stores and secondary access to mall shops. Numerous publications give design criteria for these structures, such as the ITE(22) and the National Parking Association and Urban Land Institute.(37) Depending on structure capacity, traffic control is needed at the primary garage access point intersections with the BFR. This can be 2-way Stop signs facing the access, 2-way Stop signs facing the BFR, or 4-way Stop signs facing both roads. In all cases, clear sight distance is essential.

Traffic Control Signs in General

The primary traffic signs that actually 'control' are called "regulatory". In shopping centers these are most commonly of STOP, SPEED LIMIT and NO PARKING types. Many tend to be overused or misused. They are purchased from sign specialty companies. Contact in 2012 with most of these companies found that they furnish signs fully meeting the latest standards of the Federal Highway Administration as required in the MUTCD(12) *provided the buyer so specifies.* It is therefore the responsibility of the shopping center manager when ordering to do the following:

1. Specify the type and size.
2. Require MUTCD compliance.

Once signs have arrived, the manager has the added responsibility to ensure that:

1. The signs are properly located and installed.
2. They are correctly oriented.
3. They are visible to the intended drivers, pedestrians, or bicyclists at sufficient distance to allow them to perceive, react and comply.

For new shopping centers the contractor, as overseen by the traffic engineer for the developer, has these responsibilities.

The MUTCD is too complex a document to be fully covered herein. The following is therefore a brief summary highlighting some of the most critical elements:

STOP signs are always octagonal in shape, with white lettering on a red background and reflectorized. Their standard size is 30 inches on streets, although a 24-inch size should be adequate on short, low speed road sections of a center. Sometimes narrow passages between buildings preclude use of post-mounting and the sign must be attached to a building wall. In such cases, 12-inch sizes have been used, while an intersection on a 4-land ring road should use a 36-inch size. For most regulatory signs, standard mounting height to bottom of all post-mounted signs is 7 feet, with the edge of sign at least 2 feet back of the curb face.

SPEED LIMIT signs are rectangular (as are other regulatory signs unless specifically designated otherwise - -examples YIELD is triangular, NO TURNS are square) with black lettering on a white background and reflectorized. Their standard size is 24 x 30 inches, increasing to 30x36 inches on multi-lane roads.

NO PARKING signs conventionally use red lettering on a white background and are of 12x18 inch size. However an 18x24 inch size is available, which allows longer spacing such as along a ring road. A wide variety of 'parking' signs exist - -the MUTCD shows over three dozen. Reflectorization may be excluded by the state highway agency. Use of the square 'no parking P-slash' sign is increasing, however most shopping centers use NO PARKING FIRE ZONE along the BFR. LANE USE, TURN, KEEP RIGHT AND ONE-WAY signs are also used but should be specified by the traffic engineer for the developer or shopping center manager. For example, no need exists for ONE-WAY signs at aisles having 60-degree parking.

Several unsignalized Pedestrian Ccrosswalk signs exist, such as "State Law, Stop (or Yield) to Pedestrian (symbol) Within Crosswalk". While no criteria exist at this writing for where they should be used, their placement is standardized as at the crosswalk, in the center, on a lane line or in a median island.

It is recommended that the use of all traffic control signs (and especially the regulatory types) be under the services of a traffic engineer.

Warning Signs

These signs call attention to unexpected conditions on or adjacent to roads and to situations that might not be apparent to road users. Most such signs are diamond-shaped and use black letters or symbols on a yellow background. They should always be reflectorized. Examples of types commonly used in shopping centers are DEAD END, LOW CLEARANCE, SPEED HUMP (also used in advance of Tables), STOP AHEAD (where visibility is restricted), LARGE ARROWS and CHEVRONS, LANE ENDS and advance pedestrian crossing symbol sign (which also may use a fluorescent yellow-green background).

Object markers often have application in shopping centers, particularly to warn of obstructions in or adjacent to roadways. Four general types are available in 13 configurations, so their type, location and mounting height should be determined by a traffic engineer.

Guide Signs

This type of sign has the most application to highway agency routing but has value in large shopping centers to guide truck drivers into designated access routes. Other uses include directions to anchor stores or driveways for Interstate highway connections. A special type in Regional type centers is parking section or aisle identification to aid shopper way-finding back to their parked vehicle.

The legends of guide signs are so varied that a standardized design or size is not appropriate.

Roadway Striping

The MUTCD[12] specifies the following colors and functions for markings and should be considered a legal requirement for all shopping center roads open to public travel that are not part of a parking facility:

> "Markings shall be yellow, white, red, blue or purple. The colors for markings shall conform to the standard highway colors. Black in conjunction with one of the colors mentioned in the first sentence of this paragraph shall be a usable color.
>
> When used, white markings for longitudinal lines shall delineate:
> A. The separation of traffic flows in the same direction, or
> B. The right-hand edge of the roadway.
>
> When used, yellow markings for longitudinal lines shall delineate:
> A. The separation of traffic traveling in opposite directions,
> B. The left-hand edge of the roadways of divided highways and 1-way roads or ramps, or
> C. The separation of 2-way left-turn lanes and reversible lanes from other lanes.
>
> When used, red raised pavement markers or delineators shall delineate:
> A. One-way roadways, ramps, or travel lanes that shall not be entered or used in the direction from which the markers are visible.
>
> The general functions of longitudinal lines shall be:
> A. A double line indicates maximum or special restrictions,
> B. A solid line discourages or prohibits crossing (depending on the specific application),
> C. A broken line indicates a permissive condition, and
> D. A dotted line provides guidance or warning of a downstream change in lane function.

The widths and patterns of longitudinal lines shall be as follows:

A. Normal line - -4 to 6 inches wide.
B. Wide line - -at least twice the width of a normal line.
C. Double line - -two parallel lines separated by a discernible space.
D. Broken line - -normal line segments separated by gaps.
E. Dotted line - -noticeably shorter line segments separated by shorter gaps than used for a broken line. The width of a dotted line extension shall be at least the same as the width of the line it extends."

Roadway striping has particular application to ring roads and access driveway lane use. The MUTCD specifies lane symbols, where the typical sizes may be reduced approximately one-third for low speed conditions (such as shopping centers). The word, symbol and arrow markings are normally to be white, with letters and numerals 4 feet or more in height.

REFERENCES

1. Gern, Dick; Presentation to ICSC University of Shopping Centers Convention, circa 1980.

2. Transportation Impact Analysis for Site Development, a Proposed Institute of Transportation Engineers Recommended Practice, Washington, D.C., 2005.

3. Box, Paul C.; Analysis of Traffic Impact for New Developments, *Public Works*, Feb. 1981 (Part 1) and March 1981 (Part 2).

4. Shopping Center Development Handbook, 2nd Edition, The Urban Land Institute, Washington, D.C., 1985.

5. Guidelines for Driveway Design and Location, an Institute of Transportation Engineers Recommended Practice, Washington, D.C., 1987.

6. Box, Paul C.; Effect of Intersections on Driveway Accidents, 1998 National Conference on Access Management, Transportation Research Board, Final Report, April 1999.

7. A Policy on Geometric Design of Highways and Streets, American Association of State Highway and Transportation Officials, Washington, D.C., 2001.

8. Gluck, J.S.; H.S. Levinson and V. Stover; Impact of Access Management Techniques, NCHRP Report 420, Washington, D.C., Transportation Research Board, 1999.

9. Guidelines for Planning and Designing Access Systems for Shopping Centers, Parts I and II, *Traffic Engineering*, Institute of Transportation Engineers, Washington, D.C., Jan/Feb 1975.

10. Highway Capacity Manual, Transportation Research Board, Washington, D.C., 2010.

11. Box, Paul C.; Signal Control of High-Volume Driveways, *Municipal Signal Engineer*, Nov/Dec 1965.

12. Manual on Uniform Traffic Control Devices, Federal Highway Administration, Washington, D.C., 2009.

13. Harmelink, M.D.; Volume Warrants for Left-Turn Storage Lanes at Unsignalized Grade Intersections, Highway Research Record #211, 1967.

14. Kenig, Neil; Internal Circulation and Parking at Shopping Centers, Committee 5-2, Institute of Transportation Engineers.

15. Institute of Transportation Engineers, *Traffic Engineering Handbook*, 5th Edition, Parking Chapter, ITE, Washington, D.C., 1999.

16. Box, Paul C.; Studies of Retail Building Front Roadway Traffic, *ITE Journal*, Institute of Transportation Engineers, Washington, D.C., June 2011.

17. Uniform Vehicle Code, National Committee on Uniform Traffic Laws and Ordinances, Evanston, Illinois, 1992.

18. Box, Paul C.; Parking Lot Accident Characteristics, *ITE Journal*, December 1981.

19. Welch, K.C.; Parking for Large and Small Cars, *Traffic Quarterly*, Eno Foundation for Highway Traffic Control., Jan. 1961.

20. Parking Principles, Special Report #125, Highway Research Board, Washington, D.C., 1971.

21. Nunez, Andres and Peter S. Parsonson; Safe Design of Parking Lots for Regional Shopping Centers, in Compendium of Technical Papers, ITE, Washington, D. C., 1979.

22. Guidelines for Parking Facility Location and Design, an ITE Recommended Practice, Washington, D.C., 1994.

23. Parking Lots Self-Service Data Sheet 592, National Safety Council, circa 1967.

24. Box, Paul C.; A Trip-and-Fall Hazard: Parking Lot Wheelstops; *Public Works*, May 1997.

25. English, Wm.; Slips, Trips and Falls, Safety Engineering Guidelines for the Prevention of Slip, Trip and Fall Occurrences, Hanrow Press, Del Mar, CA, 1989.

26. Standard Practice for Safe Walking Surfaces; F1637-02, ASTM International, West Conshohocken, PA, 2002.

27. Chodash, Irwin L.; Relative Efficiencies of Various Parking Angles; ITE Journal, March 1986.

28. Smith, Mary; Memo re possible update to Ref. 22; to Paul Box, John Edwards and Dick Best, 23 October 2001.

29. *Traffic Engineering Handbook*, 6th Edition, Parking Chapter, ITE, Washington, D.C., 2009

30. Box, Paul C.; Effect of Single vs Double Line Parking Stall Markings, *ITE Journal*, Washington, D.C., May 1994.

31. Mack, Paul; Separate the Stalls, One Line or Two?, *Parking Today*, Los Angeles, CA., Sept 2007.

32. Box, Paul C.; Major Road Accident Reduction by Illumination, Transportation Research Record 1247, Transportation Research Board, Washington, D.C., 1990

33. Monahan, D.R.; Safety Considerations in Parking Facilities; as presented at the International Parking Conference and Exposition and the Institutional and Municipal Parking Congress, Nashville, TN, April 1995.

34. Toaka, George; Statistical Evaluation of Brake Reaction Time, ITE Proceedings, Aug. 1982.

35. Lighting for Parking Facilities, RP20-98, Illuminating Engineering Society of North America, 1998.

36. Guidelines for Security Lighting for People, Property and Public Spaces, IESNA G-1-03, New York, 2003.

37. The Dimensions of Parking, 4th Edition, Urban Land Institute and National Parking Association, 2000. (Available through ITE with later editions).

38. Mehrabi, Armin B. and Malcolm K. Lim; NDT Verifies Garage Barrier Safety; *Parking Today*, Los Angeles, CA, June 2003.

39. Box, Paul C.; Attachments to Memo to Members of Task Force on Sites Open to Public Travel, National Committee on Uniform Traffic Control Devices, 24 October 2010.

40. National Parking Association, reprint of American Law Reports, 1971.

41. Box, Paul C. and Neil S. Kenig; Traffic Control Devices for Parking Lots, Transportation Research Record 1456, Transportation Research Board, Washington, D.C. 1994.

42. Terry, Peter A. and James J. Schuster; Tractor-Trailer Reverse movement Path; ITE Journal, Washington, D.C., November 1966.